A third point made by Professor Tait against force is, that its numerical expression is that of two ratios, — the 'space-rate of the transformation of energy,' and the 'time-rate of the generation of momentum.' These results are obtained by simple division, in an equation which expresses the fact that the work done by a body in falling the distance h is just that required to lift it through h against gravity. The fallacy involved in treating the numerical expression for force as force itself has been well exposed by Mr. W. R. Browne, in a criticism of this encyclopaedia article (*Phil. mag.*, November, 1883); and the assumption that ratios are necessarily non-existent is even more fallacious. Were it trustworthy, Professor Tait's equations would lead quite as conclusively to proofs of the non-objectivity of space and time (the former becoming the rate of work-units, the latter of motion-units, per unit of force), and so to a confirmation of the celebrated German view that whatever is universal and necessary in thought belongs to the subject, as to what he deduces from them; or they might even give mass in the form of a ratio, and hence suggest the non-objectivity of matter.

Not the least of the professor's objections against force, it would appear, is that it is 'sense-suggested.' It is a mere truism to say that no other suggestor is possible within the domain of science. It is, perhaps, better worth while to call attention to the indubitable fact that the real ground of the objection against 'action at a distance,' entertained by many physicists, is exactly that such action is not directly suggested by sense-impressions: for this is what they must really mean by calling it 'occult'; actions as our consciousness knows them, and as we can produce them, being generally characterized by proximity undistinguishable from actual contact. Further, if there is any reproach in this epithet, energy is quite as open to it as any function of energy can be: in fact, our senses directly report work in the form of nerve-disturbance, and nothing else. Force is no more truly an inference from nerve-reports testifying of energy exerted, than is matter: in fact, the inference of the independent existence of matter is the less direct and more questionable of the two. The view advocated by Mr. Browne, following Boscovitch, that matter is but 'an assemblage of central forces, which vary with distance, and not with time,' or with direction, is one of great simplicity, as well as suitability to analytic treatment, and one of which no disproof is possible.

It is not too much to claim, therefore, that, in the very difficult task of proving or disproving objective reality, Professor Tait has not here been successful.

HENRY FARQUHAR.

North-eastern and north-western Indian implements.

I do not see that it necessarily follows, because such implements as I have described as 'club-heads' were or are in use among the Ojibwas as 'bone-breakers,' that the Lenni Lenapè used these pebbles for such a purpose, and not in the manner I have suggested. It would naturally be inferred from Miss Babbitt's remarks, that the Dakota puk-gah-mah-gun never varied in its size or shape. If so, then probably no weapons of this pattern have occurred in New Jersey; but this is not true of any form of weapon, agricultural or household implement, ever made by the Indians. They vary indefinitely in size, shape, and degree of finish; and the many forms merge imperceptibly one into the other, as axes into hammers, knives into spears, and these again into arrow-heads. Miss Babbitt herself distinctly states that the two forms of 'club-head' and 'bone-breaker' are essentially the same. If the specimen I figured (fig. 212) in my 'Ancient stone implements of eastern North America' be not a club-head, it does not follow that the more nearly globular fig. 211 was not; and I am glad to be able to state that I have seen just such grooved, globular stones mounted in wooden and hide handles, that were, until very recently, in use by Sioux Indians.

I am very glad that Miss Babbitt has pointed out the use of a large number of these oval, grooved pebbles as 'bone-breakers:' it is a most desirable addition to our knowledge of the archeology of the Atlantic-coast states; and it is now possible to grade and classify this simple pattern of stone implements much more satisfactorily. Of such found in New Jersey, I would say, then, that they are, first, grooved hammers, or mauls; second, club-heads (Dakota, puk-gah-mah-gun); third, 'bone-breakers;' fourth, net-weights.

I suggest this division as based upon the size, the degree of finish, the evidence of use (as in the 'bone-breakers'), and, lastly, the conditions under which many are found. If the flat, discoidal pebbles with side-notches are net-weights, and of this there can scarcely be a doubt, then the smallest of the groove pebbles, which we usually found associated with them, were doubtless put to the same use.

CHARLES C. ABBOTT.

May 18.

Atmospheric waves from Krakatoa.

Mr. H. M. Paul is, doubtless, perfectly correct in insisting (*Science*, iii. 531) that the atmospheric waves following the Krakatoa explosion should not be confounded with the elastic waves producing sounds: in fact, these latter are so brief that it is very questionable whether they would show themselves at all on barometric traces. There would not be time enough for the mercurial barometric column to respond to the momentary compressions and rarefactions: much less would they be indicated by fluctuations extending over thirty minutes or more. The atmospheric waves which encircled the earth, and disturbed the self-registering barometric traces on the 27th of August, 1883, must therefore have been huge aerial gravity-waves, due to the enormous displacement of air produced by the ejection of vast volumes of gaseous products into the atmosphere at the time of this volcanic explosion: they were analogous to the great earthquake water-waves that are sometimes transmitted thousands of miles across oceans.

The point in this connection which needs elucidation is the fact, established by the observations of Gen. Strachey, Professor Förster, and others, that the velocity of these waves was approximately the same as that of an elastic sound-wave in air. It is the near coincidence of these velocities which has led to the confounding of these gravity-waves with elastic sound-waves. The approximate identity of the velocities in these two cases may be traced to the relation existing between the elasticity or resilience of the air, on which the velocity of sound depends, and the height of a homogeneous atmosphere, on which the velocity of long aerial gravity-waves depends.

It is well known that the mathematical investigations of Sir G. B. Airy and others, confirmed by the experimental results of Scott Russell, show, that, in the class of water-waves in which the wave-length bears a large ratio to the mean depth of the water, the velocity of propagation of the wave is sensibly

equal to the velocity acquired by a heavy body in falling vertically *in vacuo*, under the action of gravity, through half the mean depth of the water. Now, it is highly probable, that, notwithstanding the variable density of the atmosphere with altitude above the surface of the earth, the same formula is applicable to long gravity-waves propagated in it; viz., that the velocity of the wave is equal to that which a heavy body would acquire in falling vertically through half the height of a homogeneous atmosphere.

It is likewise well known, that the illustrious Newton (Principia, book ii. prop. 49), neglecting the influence of the thermal changes incident to the propagation of aerial elastic waves, deduced a most remarkable but imperfect formula for the velocity of sound in air, making it equal to that which a heavy body would acquire in falling vertically through half the height of a homogeneous atmosphere whose weight or pressure measures its elasticity.

It will be noticed that the velocity of sound by Newton's formula is precisely the same as that given by the hydrodynamical formula for long aerial gravity-waves. It is true, that, in consequence of the heat momentarily developed or absorbed during the condensations and rarefactions of the air, the actual velocity of sound exceeds that computed by the Newtonian formula by about one-sixth (a correction of the formula supplied by Laplace); yet the approximation is sufficient to seemingly co-ordinate the velocities of these diverse kinds of aerial waves.

Thus, the height of a homogeneous atmosphere, under standard conditions, being 7,990 metres, the velocity of sound computed by the Newtonian formula equals 279.96 metres per second at 0° C., and 293.5 metres per second at the August temperature of 27° C. The actual velocity of sound at above-indicated temperatures equals 332.5 and 348.6 metres per second respectively.

On the other hand, the following are some of the estimates that have been made of the velocity of the Krakatoa atmospheric waves: —

		Velocity in metres per second.
Gen. Strachey	in England	301.3 to 315.0
Professor Förster . . .	at Berlin	278.0
Mr. Renou	at Paris	246.0 to 278.0
Mr. Renou	in France	305.0 to 319.0
Mr. Wolf	at Paris	325.8
Mr. Baillaud	at Toulouse . . .	324.0
Mr. Hall	at Jamaica	308.5

All of these estimates fall decidedly short (as theory indicates) of the actual velocity of sound in air; and most of them approximate somewhat more nearly to the velocity computed by the Newtonian formula, which, as we have seen, corresponds with the hydrodynamical formula for long aerial gravity-waves.

Considering the inherent difficulties of the precise determination of the several data requisite for deducing the true velocity of the atmospheric waves originating at Krakatoa on this occasion, we need not be astonished at the considerable divergence in the estimates, or that the assumed exact coincidence of velocities of the two kinds of aerial waves fails to be verified in an accurate manner, either by theory or by observation. JOHN LECONTE.

Berkeley, Cal., May 15.

A near view of Krakatoa in eruption.

In connection with the remarkable atmospheric wave, which, starting from Krakatoa at the time of the eruption, "travelled no less than three and a quarter times round the whole circumference of the earth,"[1] the following extracts from the log of a vessel sailing in the close vicinity of Krakatoa may be of interest: —

Extracts from log of barque William H. Besse, from Batavia towards Boston.

Aug. 26. — This day commences with light airs and calms. Light airs throughout the day. At 5.30 P.M., wind hauling ahead, let go starboard anchor with thirty fathoms chain, clewed up and furled all sail. Adam light bore W. 1-4 S. and E. by S. Throughout the afternoon and night, heard heavy reports, like the discharge of heavy artillery, sounding in the direction of Java Island. Very dark and cloudy throughout the night, with continual flashes of lightning. Barometer 30.15.

Aug. 27. — Commences with strong breezes, and thick, cloudy weather. Barometer 30.12. At 9.30 A.M., pilot left ship. Hove the lead every fifteen minutes. At daylight noticed a heavy bank to the westward, which continued to rise; and, the sun becoming obscured, it commenced to grow dark. The barometer fell suddenly to 29.50, and suddenly rose to 30.60. Called all hands, furled every thing securely, and let go the port anchor with all the chain in the locker. By this time the squall struck us with terrific force, and we let go starboard anchor with eighty fathoms chain. With the squall came a heavy shower of sand and ashes, and it had become by this time darker than the darkest night. *The barometer continued to rise and fall an inch at a time.* The wind was blowing a hurricane, but the water kept very smooth. A heavy rumbling, with reports like thunder, was heard continually; and the sky was lit up with fork lightning running in all directions, while a strong smell of sulphur pervaded the air, making it difficult to breathe. Altogether, it formed one of the wildest and most awful scenes imaginable.

The tide was setting strong to the westward throughout the gale, at the rate of ten knots per hour. At 3 P.M. the sky commenced to grow lighter, although the ashes continued to fall. The barometer rose to 30.30, and dropped gradually to 30.14, when it became stationary. The whole ship, rigging and masts, were covered with sand and ashes to the depth of several inches.

Aug. 28. — Commences with light airs, and thick, smoky weather. Hove up starboard anchor, and hove short on port anchor. Dead calm throughout the day and night. Saw large quantities of trees and dead fishes floating by with the tide; the water having a whitish appearance, and covered with ashes. This day ends with a dead calm, and thick, smoky weather.

Aug. 29. — This day commences with calms, and thick, smoky weather. Made all sail throughout the day. Moderate winds, and thick, smoky weather. Passed large quantities of driftwood, cocoanuts, and dead fishes. At 8 P.M., passed Anjier,[2] and could see no light in the lighthouse, and no signs of life on shore. Furled all light sails, and stood under easy sail throughout the night. Day ends with moderate winds and cloudy weather. Barometer 30.14.

Aug. 30. — Commences with moderate winds and cloudy weather. At daylight made all sail with a fresh breeze from the westward. Found the water for miles filled with large trees and driftwood, it being almost impossible to steer clear of them. Also passed large numbers of dead bodies and fish. Kept a sharp lookout on the forecastle throughout the day.

[1] *Nature*, vol. xxx. p. 12.

[2] All except the foundation of the lighthouse was destroyed by the tidal wave.